Centripetal Force

Examine Newton's 1st and 2nd Laws of motion:

- Newton's 1st Law of Inertia states that, in the absence of an external, unbalanced force, any object will keep on doing what it's already doing. This means that a stationary object will remain stationary, and an object travelling at speed in one direction will continue on in the same direction at constant speed.
- The 2nd law explains that if an unbalanced or net force does exist on an object, that object will accelerate, with the formula relating the two quantities being $\mathbf{F_{Net} = ma}$.

In Physics 11, you learned that when an unbalanced force acts on the object and the object accelerates, it must either speed up or slow down.

But hold on: an unbalanced force can also cause an object to simply change direction. For example, if a hockey puck slides along the ice at a constant speed and hits the goal post, the force that the post exerts on the puck causes the puck to change direction. Ignoring the friction of puck-on-ice (which is pretty small), the collision between puck-and-post is the only significant force (and therefore the *net* force) affecting the puck's motion.

The centripetal acceleration of an object travelling in a circle at constant speed is caused by an unbalanced force. In this case, the net force acts *perpendicular* to the object's motion, causing it to veer out of its straight path and into a circular path. In other words, a *centripetal force* causes centripetal acceleration, or $\mathbf{F_c = ma_c}$.

To calculate centripetal force, start with $\mathbf{F_{Net} = F_c}$ for any object moving in a circular motion. If $\mathbf{F_{Net} = ma}$:

→ substitute $\mathbf{a_c} = \frac{v^2}{r}$ to get $\boxed{\mathbf{F_c = m}\frac{v^2}{r}}$

→ or, substitute $\mathbf{a_c} = \frac{4\pi^2 r}{T^2}$ to get $\boxed{\mathbf{F_c = m}\frac{4\pi^2 r}{T^2}}$

Note that these two formulas aren't on the formula sheet, but don't panic: simply add an '**m**' to the centripetal acceleration formulas.

Some kinds of forces that can act as a centripetal force include:

- the friction force that holds a child's feet to the platform of a merry-go-round while going round-and-round in a circle;
- the tension force of a rope that allows a tether ball to go around a pole without flying out.
- The gravitational force used by the Sun to keep the Earth in orbit, rather than heading out into space (and beyond).

Example #3: A 750 kg car travelling at 18.0 m/s comes to a sharp turn in the road, where the radius of the curve is 136 m.

a) Find the centripetal acceleration and force acting on the car as it begins the turn.

b) If the coefficient of static friction between tires and road is $\mu = 0.254$, will the car be able to complete the turn at this speed without sliding off the road?

(see Circular Motion Ex 3 for answer)